Supporting Information for:

Cooperative Chemical Sensing with bis-Tritylacetylenes: Pinwheel Receptors with Metal Ion Recognition Properties

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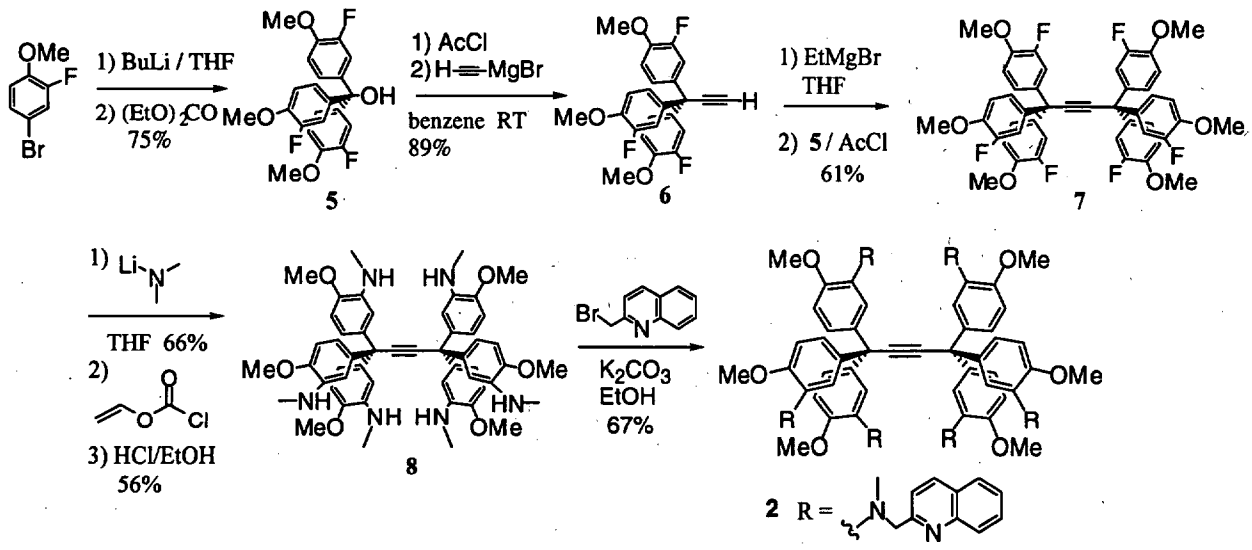


Synthesis of sensor **2** began by construction of trityl alcohol **5** from the lithiate of bromofluoroanisole (Scheme 1). The fluorine substituent is beneficial in that it offers negligible steric constraints and is readily substituted by amide nucleophiles.[1] Initial synthetic work indicated that even groups of moderate steric size at this position inhibited the formation of the highly congested framework. Chlorination of alcohol **5** followed by addition of ethynyl magnesium bromide provided the monotrityl acetylene **6** in good yield.[2] Deprotonation of the alkyne hydrogen in **6**, followed by the addition of a further equivalent of the trityl chloride derived from **5**, provided the bistrityl acetylene **7** in moderate yield. At this stage, the hexafluorinated compound **7** was treated with the lithium amide of methylamine in an effort to produce compound **8** directly. However, this reaction failed under a variety of conditions, returning only unreacted starting material. The transformation was successfully completed using a two step process. Addition of excess lithium dimethyl amide gave the hexadimethylaniline in good yield. The rational for including the methoxy substituent is now apparent as it is necessary to avoid regiochemical complications due to potential benzyne formation in this reaction. Selective mono-dealkylation of the dimethylaniline moieties was accomplished using a modification of an Olofson procedure to yield compound **8**.[3] Alkylation with the known bromomethylquinoline[4] afforded the final sensor **2**. Compound **3** was prepared using obvious extensions of this procedure. Compound **4** was prepared from bisanilinoethane according to the method of Steiman.[4]

General Methods

All reactions were carried out in oven dried glassware under an argon atmosphere. Tetrahydrofuran (THF) and benzene were distilled from sodium benzophenone ketyl under argon immediately before use. Toluene was distilled from sodium under argon immediately before use. Flash chromatography[5] was performed with 32-63 μm silica gel. All melting points are uncorrected. NMR spectra were recorded on a Bruker AMX-360 or DRX-400 NMR using TMS as a reference.

Tris(3-fluoro-4-methoxyphenyl)carbinol (5)

2-Fluoro-4-bromoanisole (12.6 ml, 99.6 mmol) and THF (400 ml) were placed in a 1000 ml round bottom flask under argon and cooled to -78°C. n-Butyl lithium (65 ml, 1.6 M, 99.6 mmol) was added over 10 minutes. The reaction stirred for 5 minutes and diethyl carbonate (3.54 ml, 29.2 mmol) was added via syringe. The reaction was allowed to warm to 0°C over 1 hour. Saturated NH_4Cl solution (200 ml) was added. The mixture was extracted with ether (3 x 100 ml), dried over $MgSO_4$ and concentrated. The residue was chromatographed on silica with a gradient of 20-35% ethyl acetate in hexane to afford compound **5** as a yellow oil (10.6 g, 75% yield) which solidified upon standing. m.p. = 99-101 °C; ^{1}H NMR ($CDCl_3$, 360 MHz) δ 7.01 (dd, $J_{H\text{-}F}$ = 12.3, $J_{H\text{-}H}$ = 1.8 Hz, 3 H), 6.93 (dd, J = 8.7, 2.3 Hz, 3H), 6.89 (t, $J_{H\text{-}F} = J_{H\text{-}H}$ = 8.7 Hz, 3H), 3.89 (s, 9H), 2.67 (s, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 151.8 (d, $J_{C\text{-}F}$ = 246 Hz), 146.9 (d, $J_{C\text{-}F}$ = 10.7 Hz), 139.4 (d, $J_{C\text{-}F}$ = 4.9 Hz), 123.5 (d, $J_{C\text{-}F}$ = 3.9 Hz), 115.8 (d, $J_{C\text{-}F}$ = 20.4 Hz), 112.7, 80.3, 56.3; IR (neat) 3500, 2937, 2842, 1512, 1274, 1123, 1027, 799, 762 cm^{-1}; CIMS (relative intensity) *m/z* 405 (MH^+, 48), 387 (M-OH, 100); HMRS calcd. for $C_{22}H_{18}F_3O_3$ (M-OH): 387.1208, found: 387.1196.

3,3,3-Tris(3-fluoro-4-methoxyphenyl)propyne (6)

Compound **5** (1.7 g, 4.2 mmol) and acetyl chloride (20 ml) were placed in a 250 ml round bottom flask fitted with a drying tube and stirred at room temperature for 2 hours. The acetyl chloride was removed in vacuo. Toluene (60 ml) was added and removed in vacuo (to remove the last traces of acetic acid). Toluene (125 ml) was then added. The reaction was cooled to -78°C and ethynyl magnesium bromide (15 ml, 0.5 M in THF, 7.5 mmol) was then added via syringe. The reaction was allowed to warm to room temperature over night. Saturated NH_4Cl solution (100 ml) was added. The mixture was extracted with ether (3 x 75 ml), dried over $MgSO_4$ and concentrated. The residue was chromatographed on silica with 20% ethyl acetate in hexane to afford compound **6** as an off-white solid (1.54 g, 89% yield). m.p. = 135-137 °C; ^{1}H NMR ($CDCl_3$, 360 MHz) δ 7.00 (dd, $J_{H\text{-}F}$ = 12.5, $J_{H\text{-}H}$ = 2.3 Hz, 3H), 6.92 (dd, J = 8.7, 2.3 Hz, 3H), 6.87 (t, $J_{H\text{-}F} = J_{H\text{-}H}$ = 8.7 Hz, 3H), 3.89 (s, 9H), 2.73 (s, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 151.9 (d, $J_{C\text{-}F}$ = 246 Hz), 146.7 (d, $J_{C\text{-}F}$ = 10.7 Hz), 137.2 (d, $J_{C\text{-}F}$ = 5.8 Hz), 124.5, 116.9 (d, $J_{C\text{-}F}$ = 20.4 Hz), 112.7, 88.6, 74.0, 56.3, 52.9; IR (neat) 3296, 2936, 2841, 1511, 1278, 1122, 1027, 762 cm^{-1}; HMRS calcd. for $C_{24}H_{19}F_3O_3$ (MH^+): 413.1365, found: 413.1361.

1,1,1,4,4,4-Hexakis(3-fluoro-4-methoxyphenyl)butyne (7)

Compound **5** (1.0 g, 2.47 mmol) and acetyl chloride (10 ml) were placed in a 250 ml round bottom flask fitted with a drying tube and stirred at room temperature for 1 hour. The acetyl chloride was removed in vacuo and toluene (60 ml) was added. The solvent was removed in vacuo (to remove the last traces of acetic acid) and toluene (60 ml) was added. Compound **6** (963 mg, 2.34 mmol) and THF (8 ml)

were placed in a separate 25 ml pear shaped flask under argon. Ethyl magnesium bromide (0.78 ml, 3 M in ether, 2.34 mmol) was added via syringe and the reaction was stirred for 2 hours. The THF solution was then transferred via cannula to the toluene solution and the reaction was stirred at room temperature overnight, then heated to 40°C for 3 hours. Saturated NH_4Cl (50 ml) solution was added. The mixture was extracted with ether (3 x 50 ml), dried over $MgSO_4$ and concentrated. The residue was chromatographed on silica with a gradient of 30-40% ethyl acetate in hexane to afford compound **7** as a white solid (1.14 g, 61% yield). m.p. = 88-89 °C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 7.00 (d, J = 13.7 Hz, 6H), 6.89-6.84 (m, 12H), 3.89 (s, 18H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 151.9 (d, $J_{C\text{-}F}$ = 247 Hz), 146.7 (d, $J_{C\text{-}F}$ = 10.8 Hz), 137.7 (d, $J_{C\text{-}F}$ = 5.4 Hz), 124.5 (d, $J_{C\text{-}F}$ = 3.6 Hz), 116.9 (d, $J_{C\text{-}F}$ = 19.7 Hz), 112.8, 90.4, 56.3, 53.7; IR (neat) 2935, 2840, 1510, 1276, 1122, 1028, 762 cm^{-1}; CIMS (relative intensity) *m/z* 798 (M^+, 48), 387 (100); Anal. Calcd for $C_{46}H_{36}F_6O_6$: C, 69.17; H, 4.54. Found: C, 68.93; H, 4.64.

1,1,1,4,4,4-Hexakis(3-methylamino-4-methoxyphenyl)but-2-yne (8)

Compound **7** (250 mg, 0.313 mmol) and THF (50 ml) were placed in a 250 ml round bottom flask under argon and cooled to -78°C. Lithium dimethylamide (2.35 ml, 10% dispersion in hexanes, 3.13 mmol) was added via syringe. The reaction was allowed to warm to room temperature overnight. Saturated $NaHCO_3$ solution (50 ml) was added. The mixture was extracted with ether (3 x 50 ml), dried over $MgSO_4$ and concentrated. The residue was chromatographed on silica with 6:8:1 ethyl acetate : hexane : triethyl amine to afford 1,1,1,4,4,4-Hexakis(3-dimethylamino-4-methoxyphenyl)but-2-yne as an off white solid (197 mg, 66% yield). m. p. = 73-76°C; ^{1}H NMR ($CDCl_3$, 400 MHz) δ 6.97 (d, J = 2.0 Hz, 6H), 6.75 (dd, J = 8.2, 2.0 Hz, 6H), 6.68 (d, J = 8.5 Hz, 6H), 3.84 (s, 18H), 2.52 (s, 36H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 150.8, 141.4, 138.6, 122.8, 119.5, 109.7, 91.4, 55.3, 54.6, 43.2; IR (neat) 2943, 2828, 2780, 1505, 1241, 1195, 1119, 1030, 727 cm^{-1}; HMRS calcd. for $C_{58}H_{73}N_6O_6$ (MH^+): 949.5592, found: 949.5583; Anal. Calcd for $C_{58}H_{72}N_6O_6$: C, 73.39; H, 7.65; N, 8.85. Found: C, 73.36; H, 7.79; N, 8.79.

1,1,1,4,4,4-Hexakis(3-dimethylamino-4-methoxyphenyl)but-2-yne (77 mg, 0.081 mmol) and vinyl chloroformate (1 ml) were place in a 10 ml resealable tube which was flushed with argon and sealed. The tube was heated to 115°C in an oil bath for 3 hours. The mixture was concentrated and the residue was taken up in ethanol (8 ml). HCl (conc, 4 ml) was added and the reaction heated to 50°C for 5 hours. The reaction was cooled, basified with aqueous NaOH and extracted with CH_2Cl_2. The extracts were dried over $MgSO_4$ and concentrated. Chromatography on silica with 3:7:1 ethyl acetate : hexane : triethyl amine afforded compound **8** as a white solid (39 mg, 56% yield). m. p. = 265 °C (dec.); ^{1}H NMR ($CDCl_3$, 360 MHz) δ 6.97 (d, J = 2.0 Hz, 6H), 6.75 (dd, J = 8.2, 2.0 Hz, 6H), 6.68 (d, J = 8.5 Hz, 6H), 3.84 (s, 18H), 2.52 (s, 18H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 145.3, 139.8, 138.3, 117.3, 111.7, 107.9, 91.6, 55.4, 55.3, 30.1; IR (neat) 3411, 2933, 1602, 1520, 1258, 1226, 1164, 1030 cm^{-1}; HMRS calcd. for $C_{52}H_{60}N_6O_6$ (MH^+): 865.4653, found: 865.4662.

1,1,1,4,4,4-Hexakis(3-(N-methyl-N-(quinoline-2-methyl)amino)-4-methoxyphenyl)but-2-yne (2)

Compound **8** (39 mg, 0.045 mmol), bromomethylquinoline (204 mg, 0.92 mmol), K_2CO_3 (128 mg, 0.92 mmol) and ethanol (10 ml) were placed in a round bottom flask with a condenser and drying tube. The reaction was heated to 50 °C for 5 hours. The solvent was removed in vacuo and the residue was chromatographed on silica with 15 : 4 : 1 ethyl acetate : hexane : triethyl amine to afford compound **2** as a light yellow oil (52 mg, 67% yield). ^{1}H NMR ($CDCl_3$, 360 MHz) δ 8.01 (d, J = 8.7 Hz, 6H), 7.95 (d, J = 8.2 Hz, 6H), 7.72 (d, J = 8.2 Hz, 6H), 7.62 (td, J = 6.8, 1.3 Hz, 6H), 7.60 (d, J = 8.7 Hz, 6H), 7.44 (td, J = 8.0, 1.3 Hz, 6H), 7.04 (d, J = 2.3 Hz, 6H), 6.70 (dd, J = 8.2, 2.3 Hz, 6H), 6.56 (d, J = 8.2 Hz, 6H), 4.34 (s, 12H), 3.75 (s, 18H), 2.38 (s, 18H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 160.9, 150.5, 147.4, 140.6, 138.6, 136.1, 129.1, 128.9, 127.4, 127.3, 125.8, 122.3, 120.8, 120.1, 110.1, 91.6, 61.8, 55.4, 54.6, 39.3. IR (neat) 3060, 2934, 2834, 1599, 1503, 1241, 1147, 1241, 1147, 1029, 910, 830, 731 cm^{-1}; HMRS calcd. for $C_{112}H_{102}N_{12}O_6$ (M^+): 1710.8045, found: 1170.8047.

3,3,3,-Tris(3-dimethylamino-4-methoxyphenyl)propyne

Compound **6** (250 mg, 0.607 mmol) and THF (75 ml) were placed in a 250 ml round bottom flask under argon and cooled to -78°C. Lithium dimethylamide (9.1 ml, 10% dispersion in hexanes, 12.1 mmol) was added via syringe. The reaction was allowed to warm to room temperature overnight. Saturated $NaHCO_3$ solution (50 ml) was added. The mixture was extracted with ether (3 x 50 ml), dried over $MgSO_4$ and concentrated. The residue was chromatographed on silica with 10-20% ether in dichloromethane to afford the title compound as an oil (128 mg, 43% yield). ^{1}H NMR ($CDCl_3$, 360 MHz) δ 6.86 (d, J = 2.3 Hz, 3H), 6.70 (dd, J = 8.2, 2.3 Hz, 3H), 6.65 (d, J = 8.6 Hz, 3H), 3.78 (s, 9H), 2.61 (s, 18H), 2.59 (s, 1H); ^{13}C NMR ($CDCl_3$, 90 MHz) δ 151.0, 141.5, 137.6, 122.8, 119.4, 109.8, 90.5, 72.5, 55.2, 54.1, 43.2; IR (neat) 3279, 2941, 2829, 2780, 1597, 1504, 1461, 1242, 1196, 1119, 1029, 727 cm^{-1}; HMRS calcd. for $C_{30}H_{38}N_3O_3$ (MH^+): 488.2913, found: 488.2898.

3,3,3-Tris(3-methylamino-4-methoxyphenyl)propyne

3,3,3,-Tris(3-dimethylamino-4-methoxyphenyl)propyne (74 mg, 0.152 mmol) and vinyl chloroformate (1 ml) were place in a 10 ml resealable tube which was flushed with argon and sealed. The tube was heated to 115°C in an oil bath for 4 hours. The mixture was concentrated and the residue was taken up in ethanol (8 ml). HCl (conc, 4 ml) was added and the reaction heated to 50°C for 5 hours. The reaction was cooled, basified with aqueous NaOH (aqu.) and extracted with CH_2Cl_2. The extracts were dried over $MgSO_4$ and concentrated. Chromatography on silica with 0-2% ethyl ether in dichloromethane afforded the title compound as a an oil (36 mg, 53% yield). ^{1}H NMR ($CDCl_3$, 360 MHz) δ 6.75 (d, J = 2.3 Hz, 3H), 6.60 (d, J = 8.2 Hz, 3H), 6.43 (dd, J = 8.2, 2.3 Hz, 3H), 3.81 (s, 9H), 2.74 (s, 9H), 2.64 (s, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 145.7, 138.6, 138.5, 117.3, 111.1, 108.0, 91.3, 72.1, 55.4, 54.8, 30.4; IR (neat) 3426, 3281, 2935, 1602, 1520, 1409, 1258, 1227, 1164, 1029, 909, 789, 731 cm^{-1}; HMRS calcd. for $C_{27}H_{32}N_3O_3$ (MH^+): 446.2444, found: 446.2409.

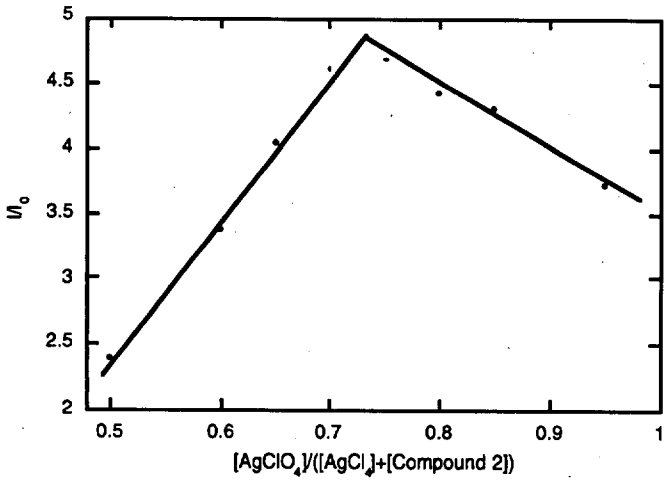
3,3,3-Tris(3-(N-methyl-N-(quinoline-2-methyl)amino)-4-methoxyphenyl)propyne (3)

3,3,3-Tris(3-methylamino-4-methoxyphenyl)propyne (36 mg, 0.081 mmol), bromomethylquinoline (179 mg, 0.81 mmol), K_2CO_3 (112 mg, 0.81 mmol) and ethanol (4 ml) were placed in a round bottom

flask with a condenser and drying tube. The reaction was heated to 50 °C for 2 hours and allow to stir at room temperature over night. The solvent was removed in vacuo and the residue was chromatographed on silica with 40% ethyl ether in methylene chloride to afford compound **3** as a light yellow oil (24 mg, 34% yield). ^{1}H NMR ($CDCl_3$, 360 MHz) δ 8.08 (t, J = 8.6 Hz, 6H), 7.79 (d, J = 8.1 Hz, 3H), 7.70-7.66 (m, 6H), 7.50 (t, J = 6.6, 1.3 Hz, 3H), 7.01 (s, 3H), 6.63 (s, 6H), 4.48 (s, 6H), 3.83 (s, 9H), 2.66 (s, 9H), 2.53 (s, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ 160.7, 150.8, 147.5, 140.6, 137.6, 136.1, 129.2, 128.9, 127.5, 127.3, 125.9, 122.5, 120.7, 120.2, 110.0, 90.2, 72.8, 61.8, 55.4, 54.1, 39.8. IR (neat) 3291, 2925, 2853, 1598, 1503, 1242, 1148, 1027, 829, 744 cm^{-1}; HMRS calcd. for $C_{57}H_{53}N_6O_3$ (MH^+): 869.4179, found: 869.4193.

Fluorescence Studies

Fluorescence spectra were recorded on a Shimadzu RF-5301 PC spectrofluorimeter at ambient temperature. Excitation was 235 nm in all cases with the excitation slit width at 5 nm and the emission slit width at 20 nm. All solutions were prepared in acetonitrile with the indicated concentration of Me_4NClO_4 as an ionic strength buffer. Solutions were mixed immediately prior to obtaining each spectrum due to the observation of a small amout of photobleaching.



Stoichiometry was determined by a Job analysis.[6] The concentration of Ag(I) and compound **2** was maintained at 10 μM in acetonitrile with 50 mM Me_4NClO_4 as an ionic strength buffer. The curve reaches a maximum at 73% Ag(I) which is consistent with 3:1 binding.

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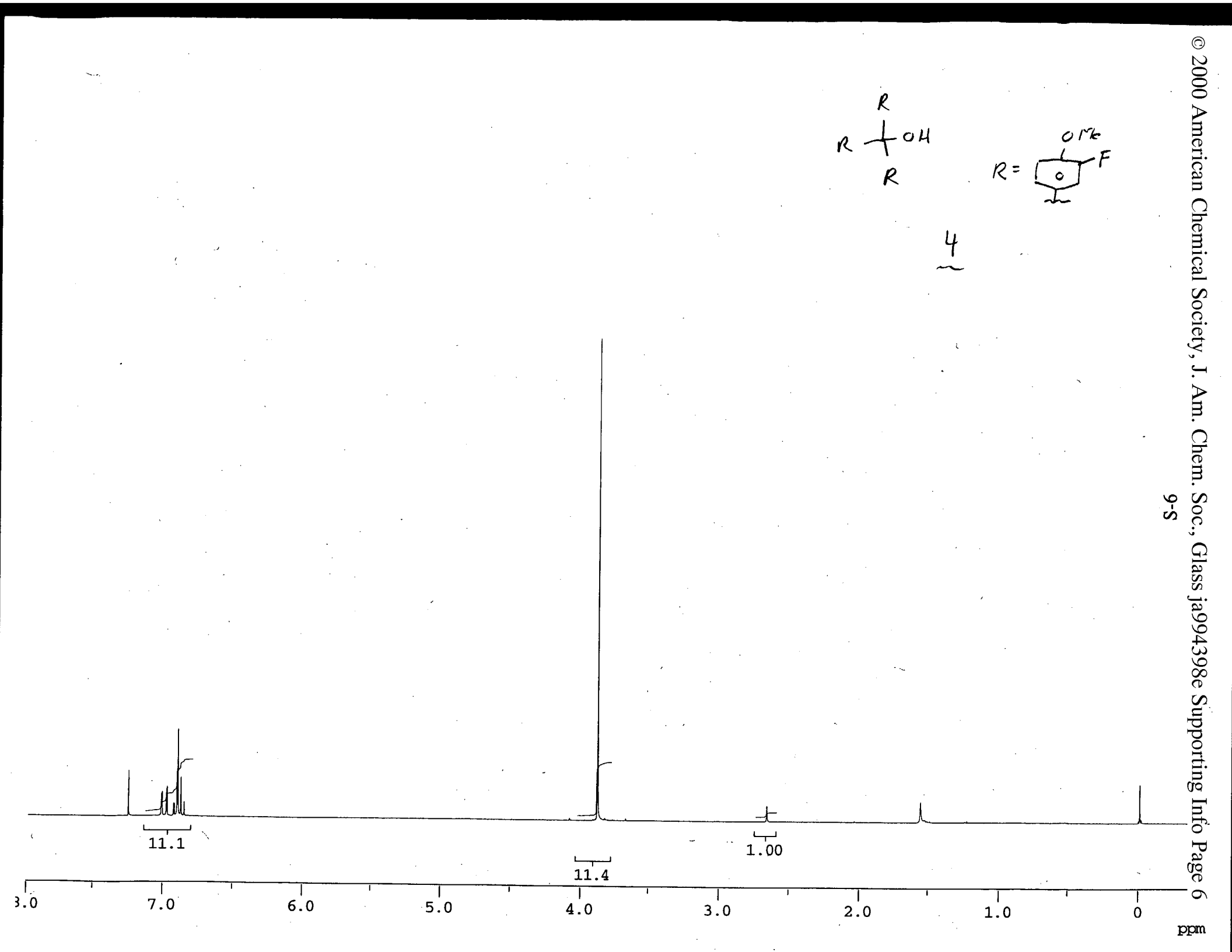

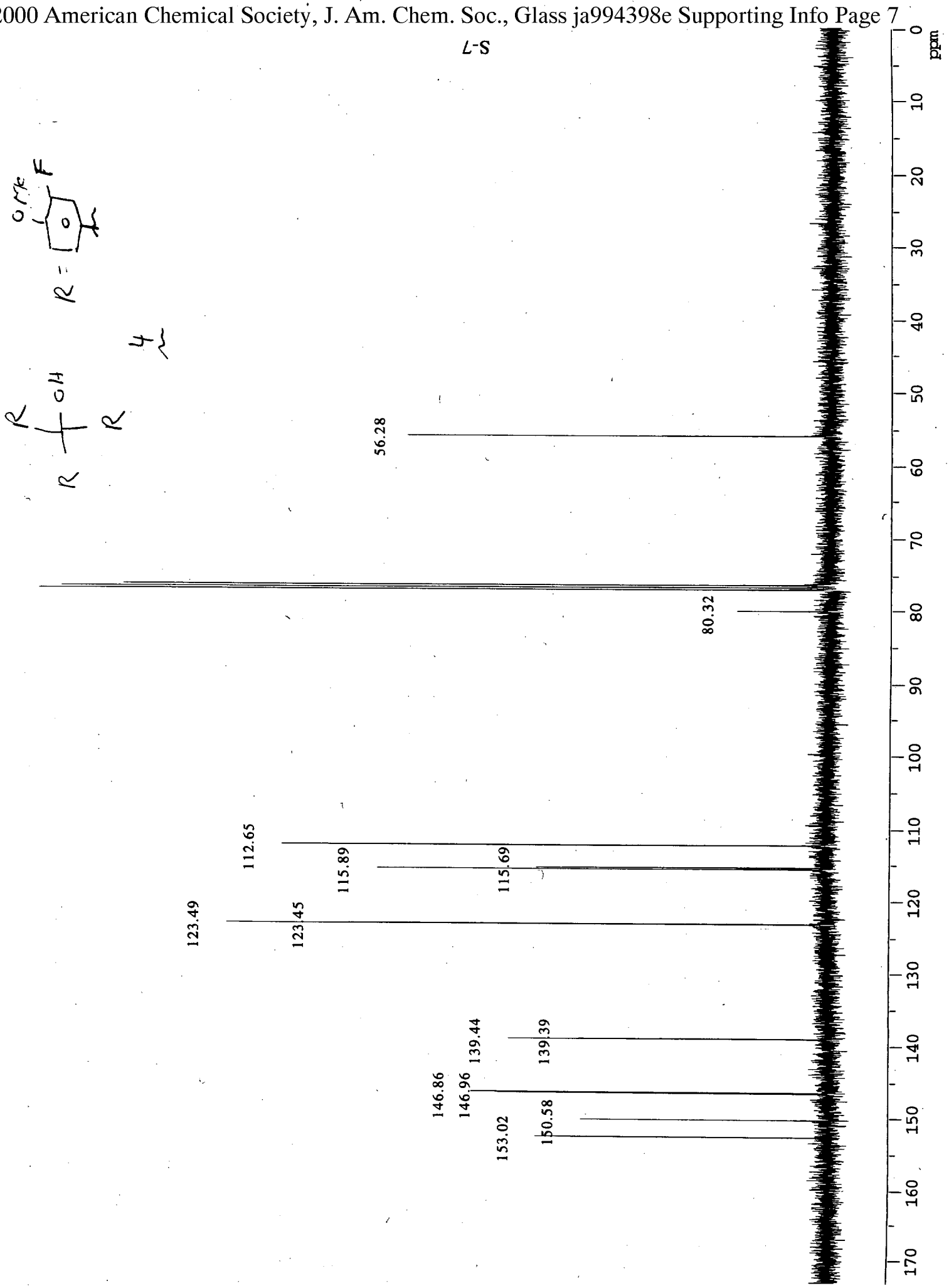

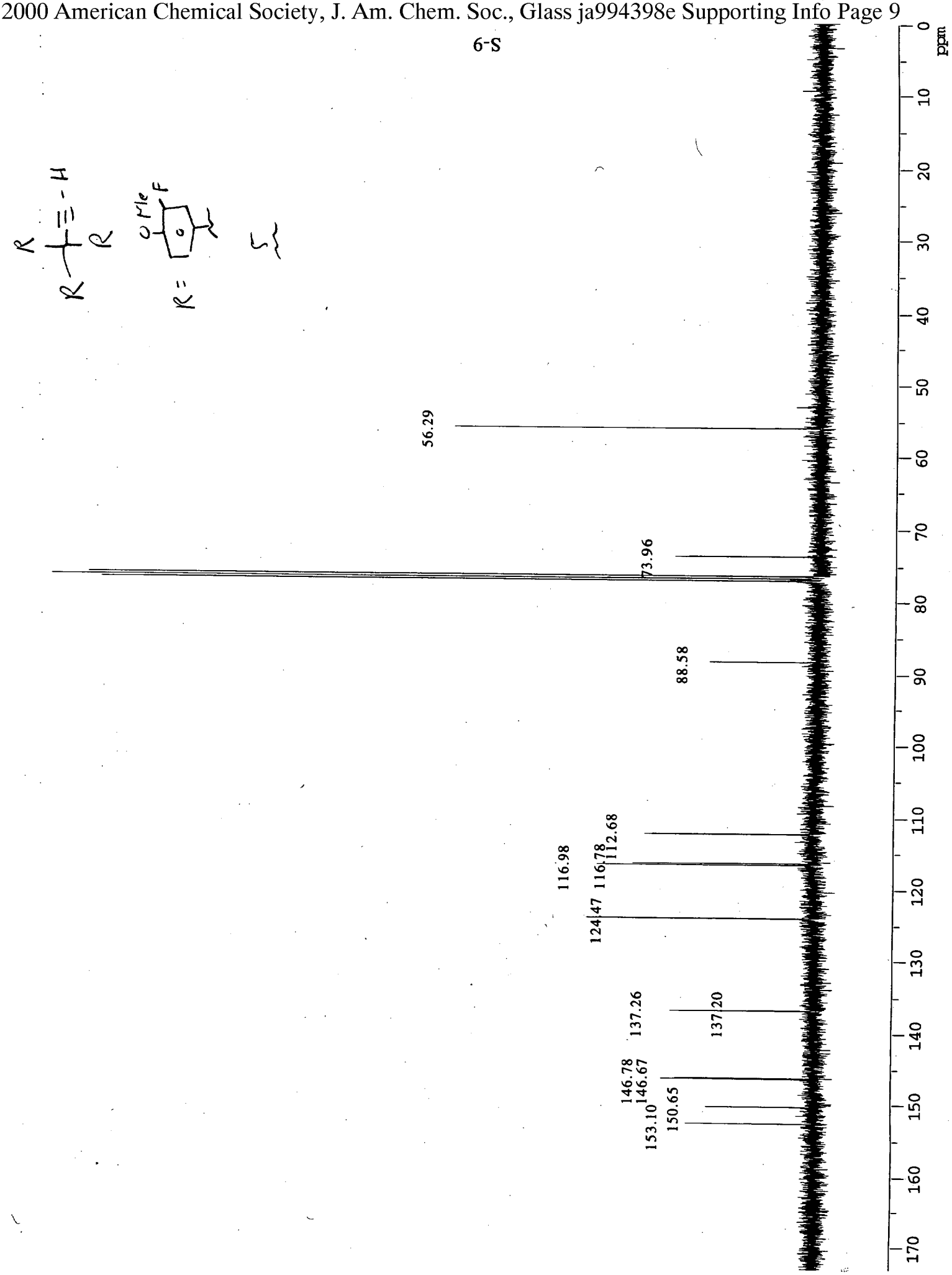

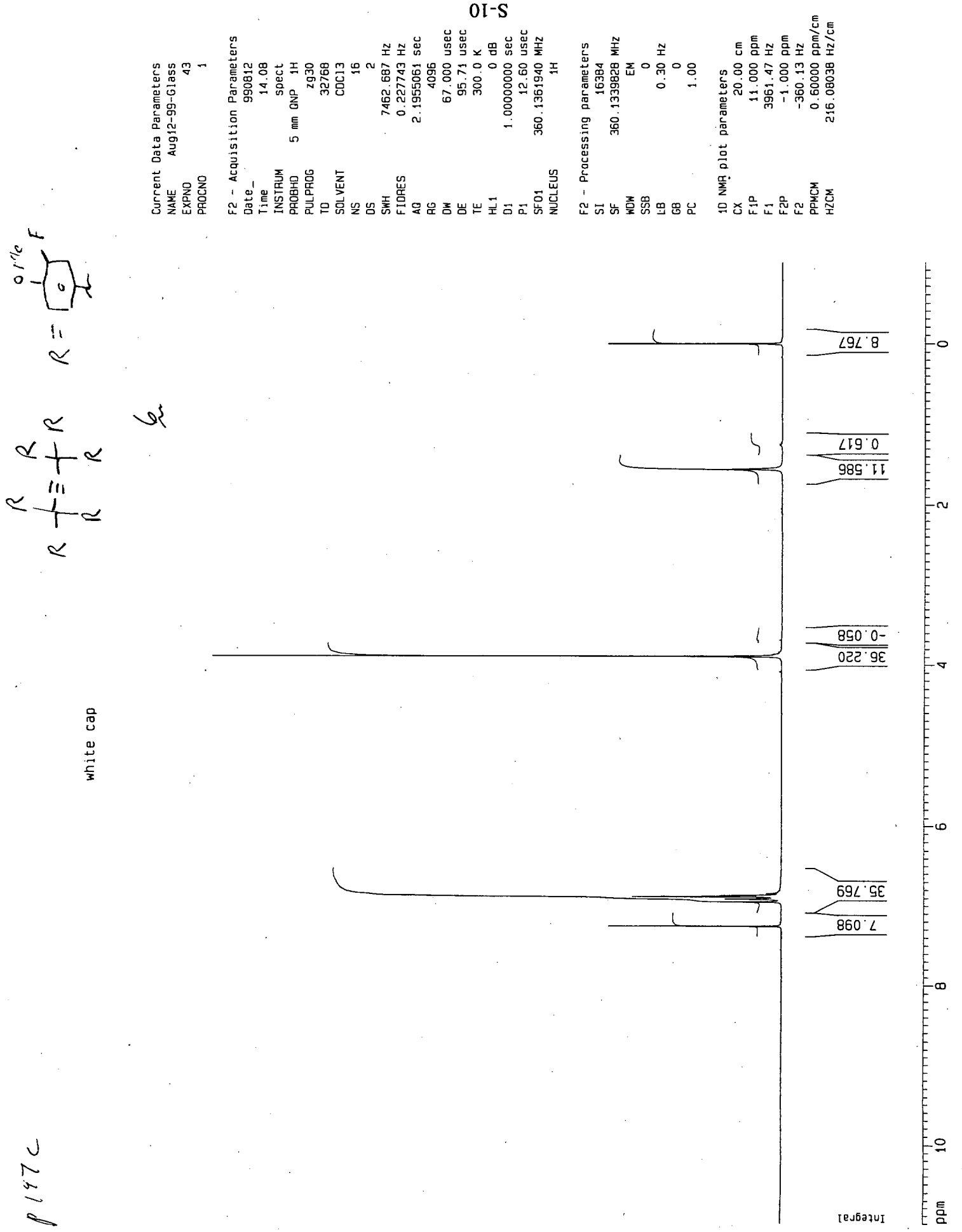

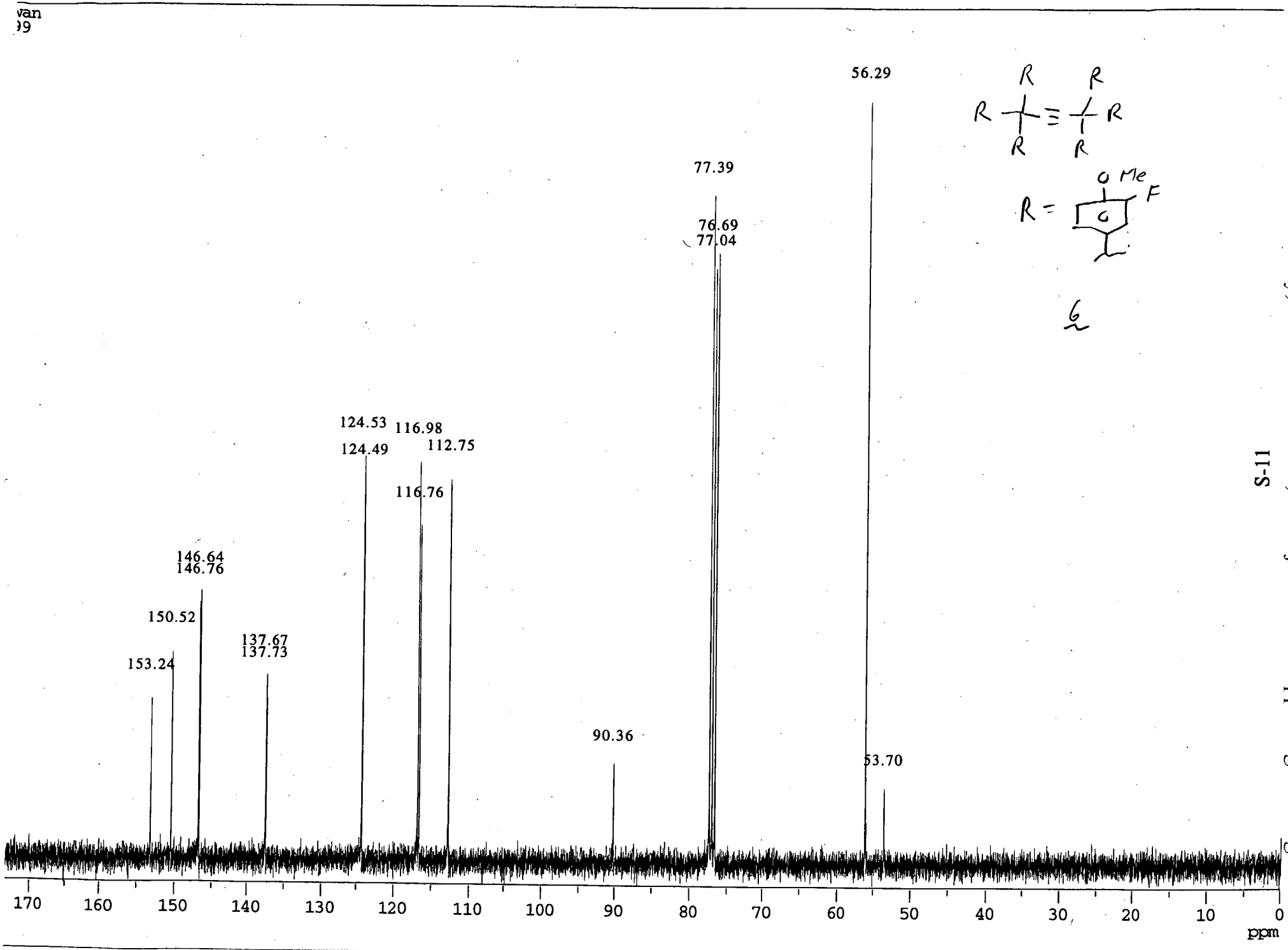

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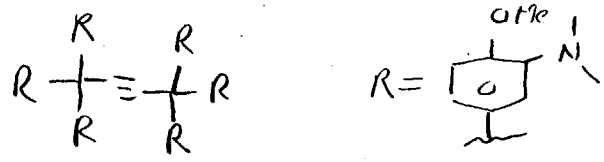

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^^^ PEAKS ^^^ no.	ppm	Hz	intensity
1	6.969	2788.35	2353.00
2	6.964	2786.34	2196.63
3	6.765	2707.03	966.90
4	6.759	2704.52	849.84
5	6.744	2698.50	1627.24
6	6.739	2696.49	1393.83
7	6.688	2675.91	2647.22
8	6.666	2667.38	1563.99
9	3.843	1537.53	11736.45
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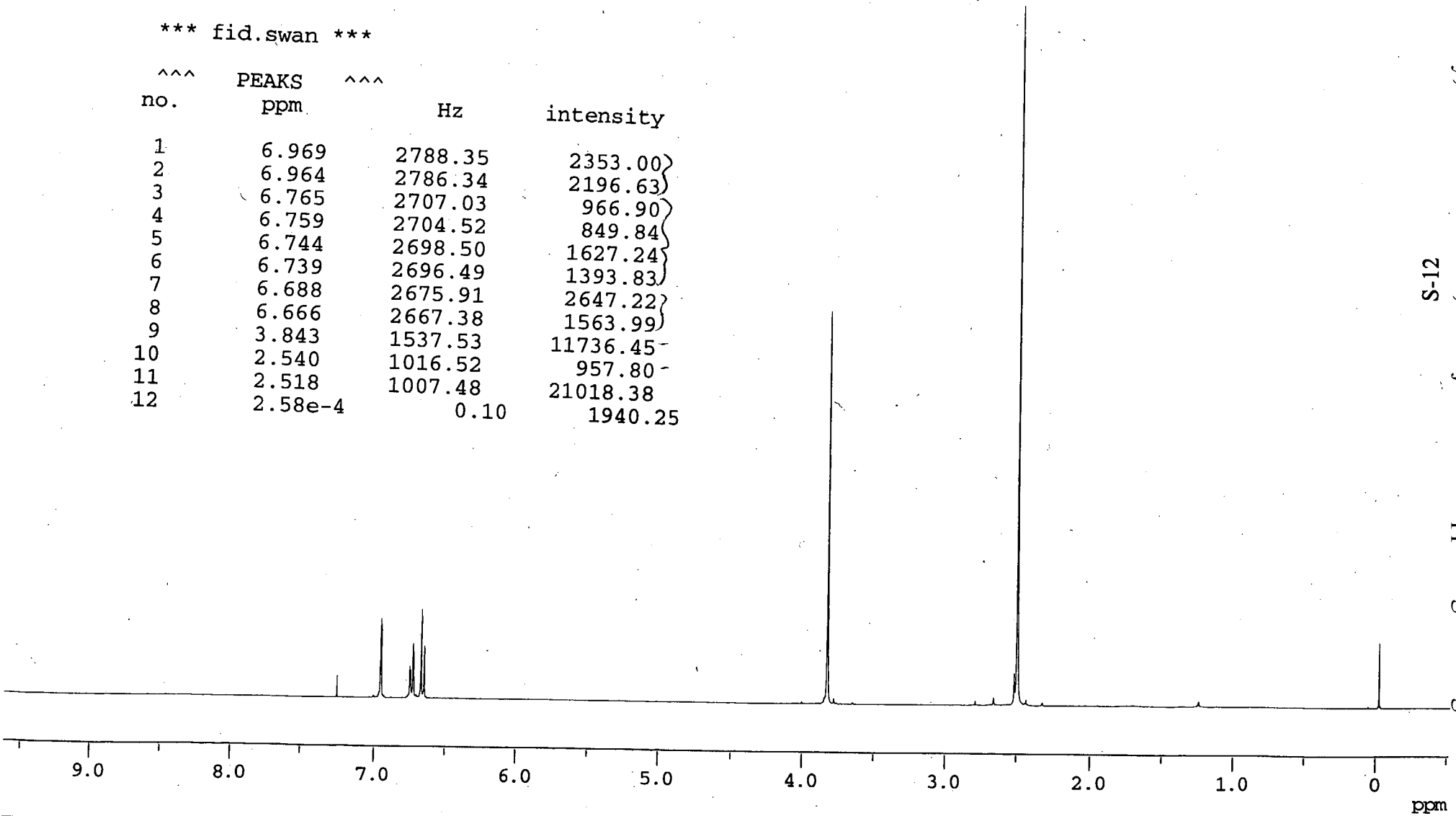

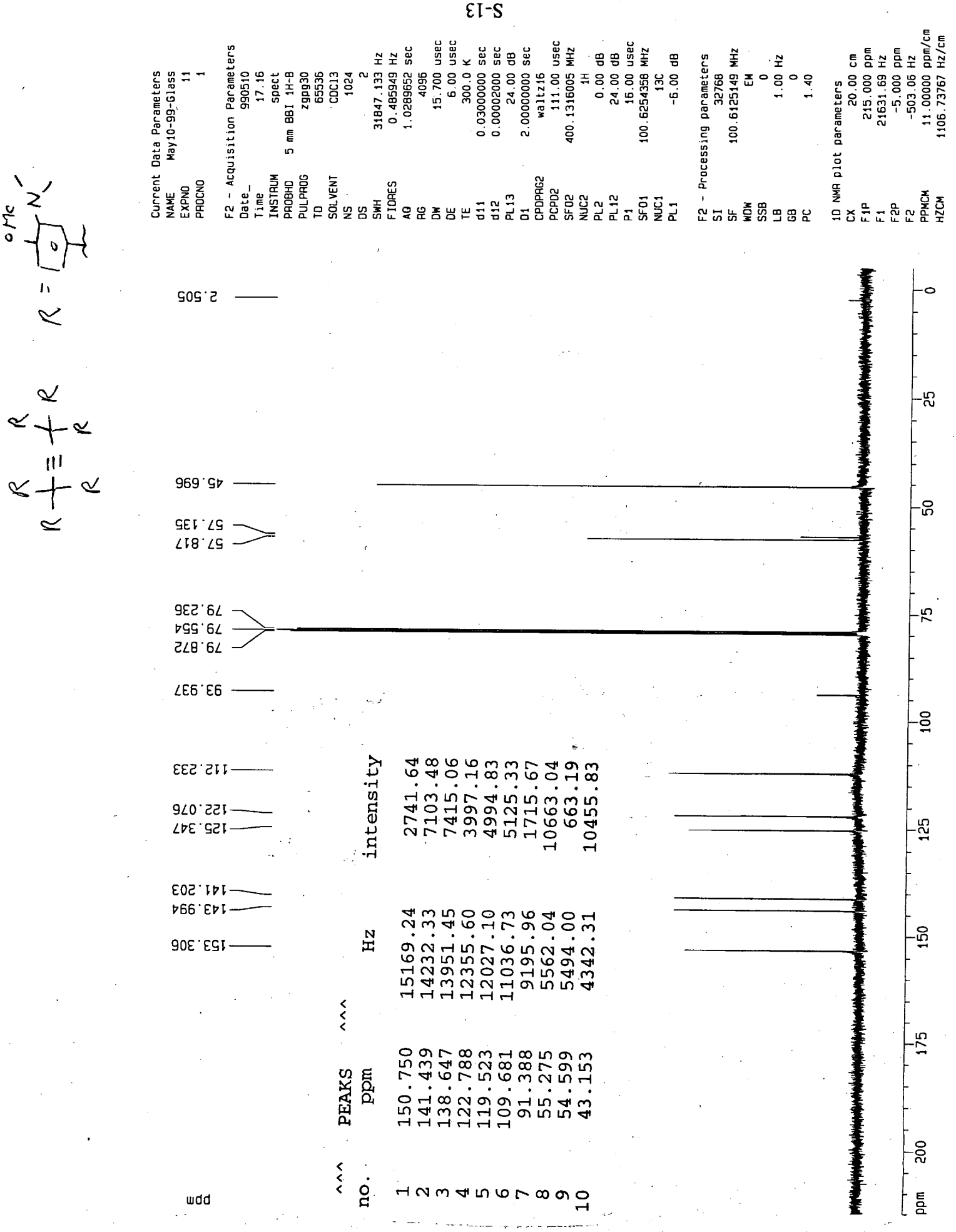

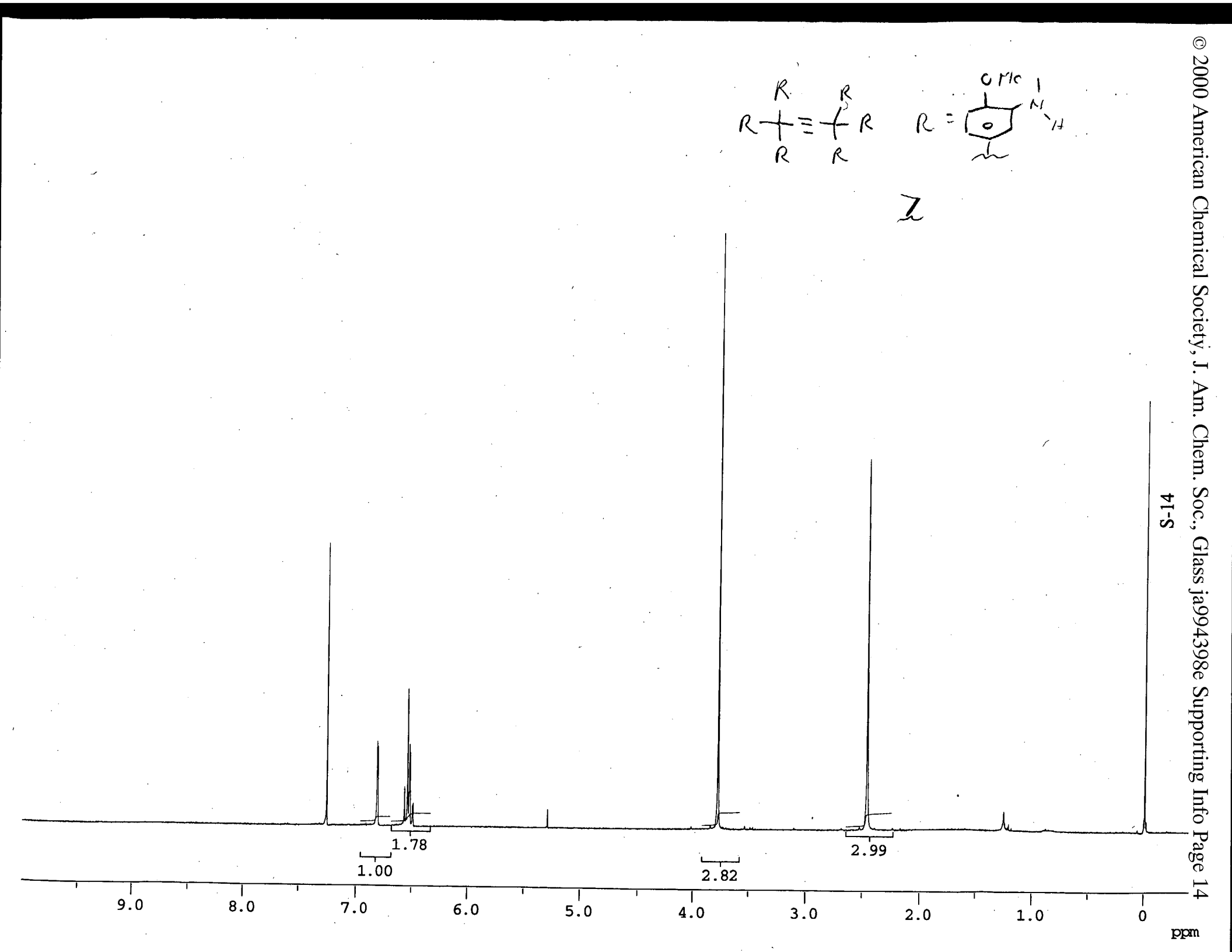

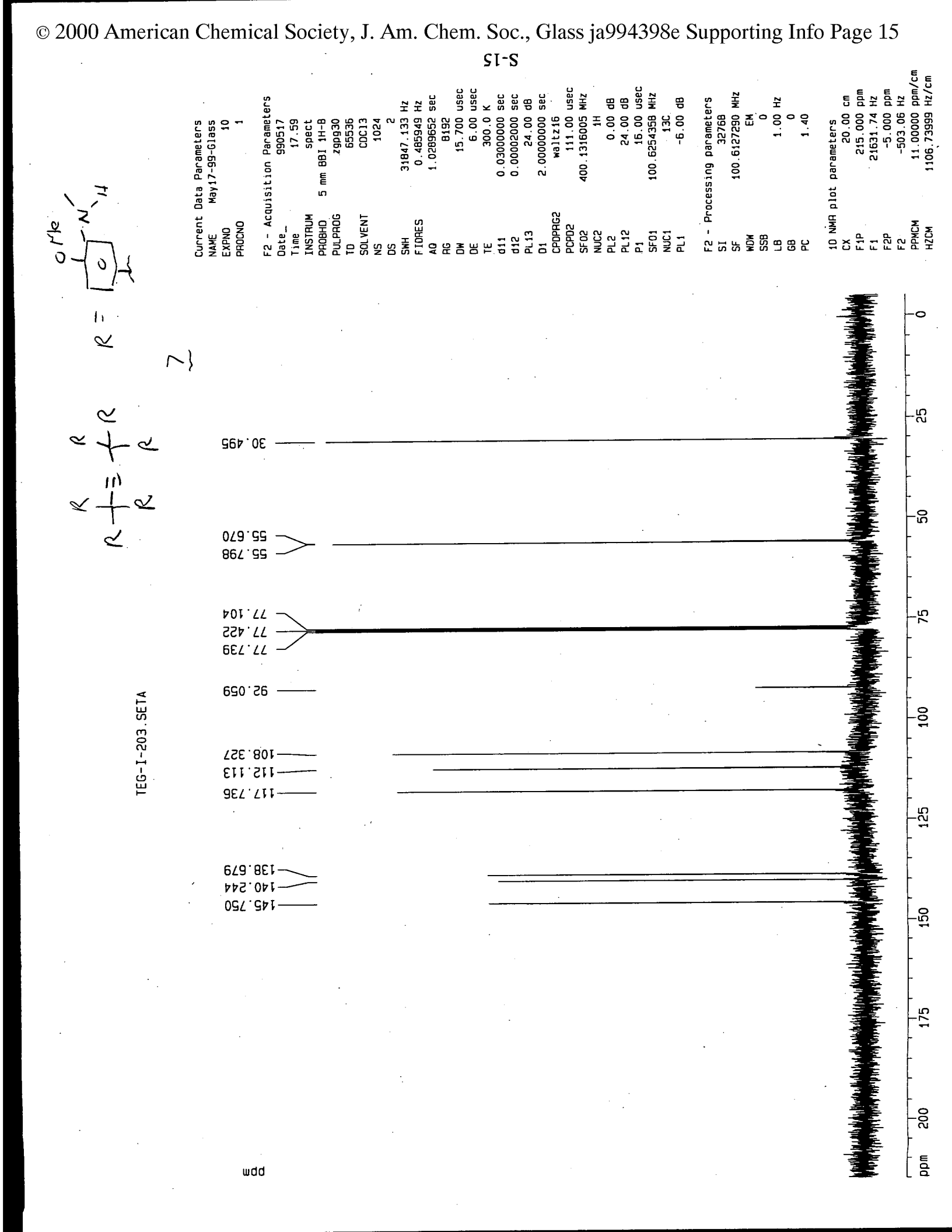

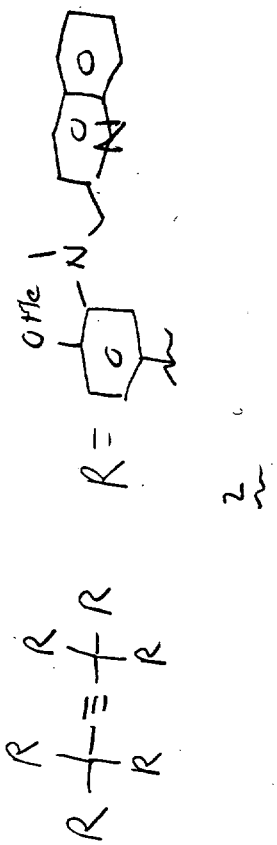

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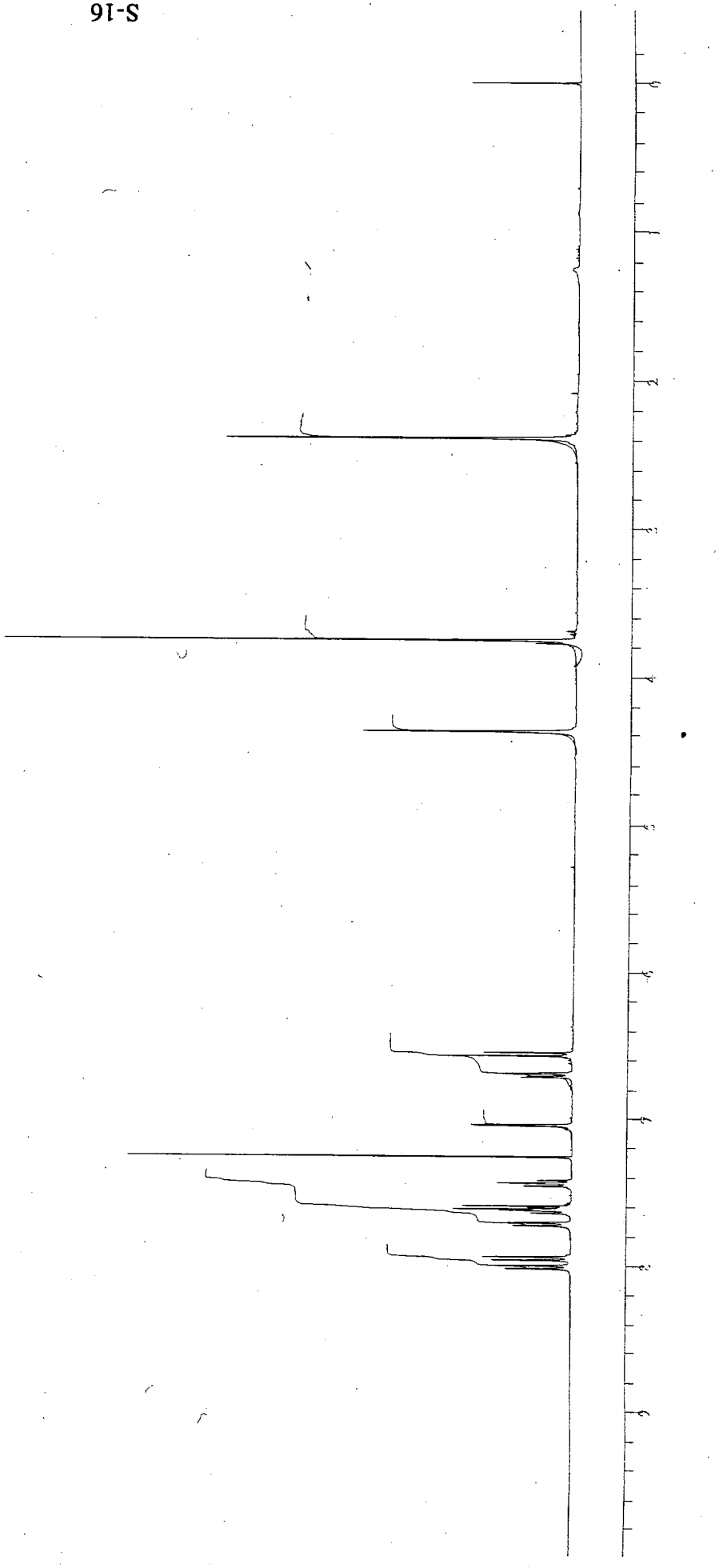

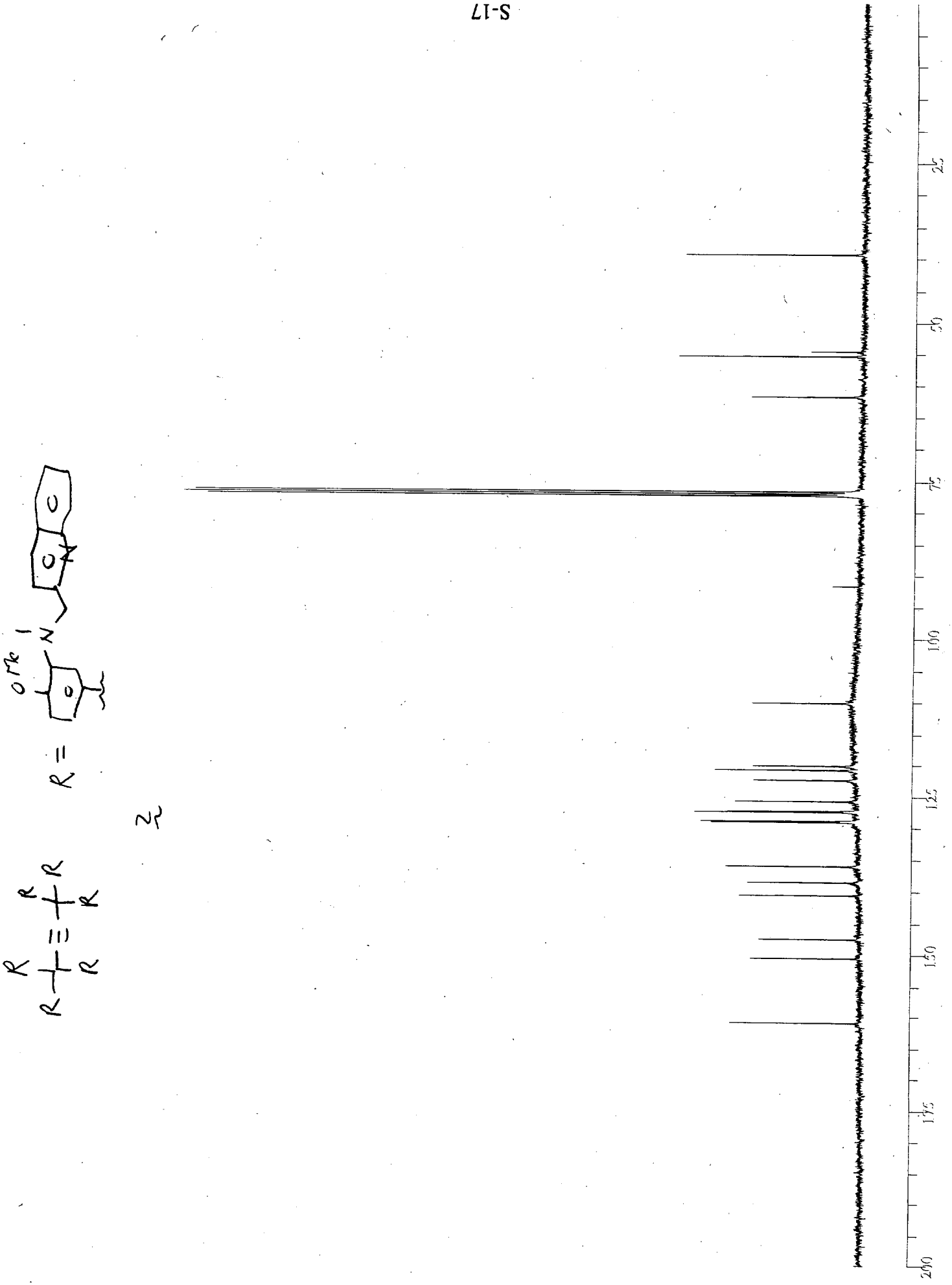

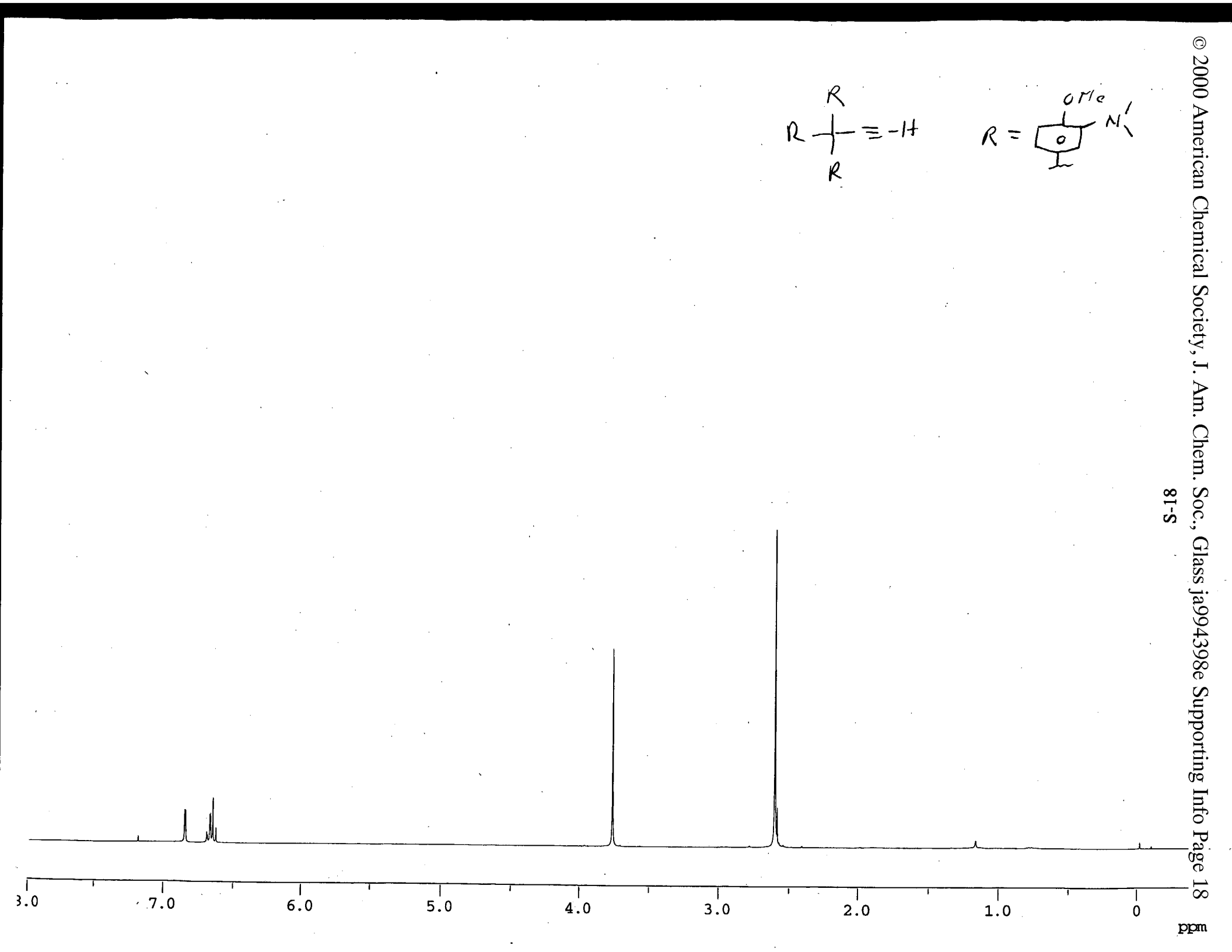

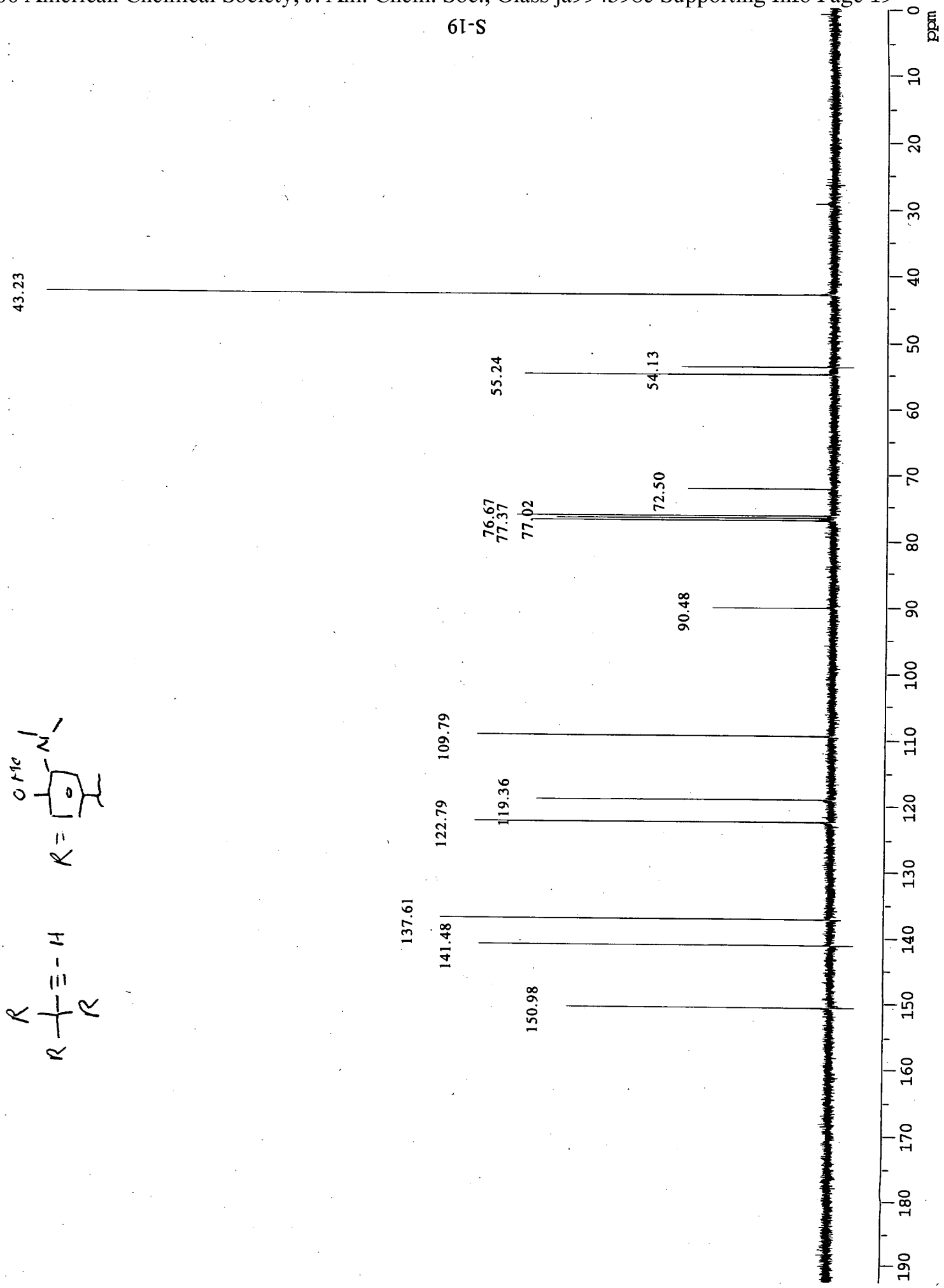

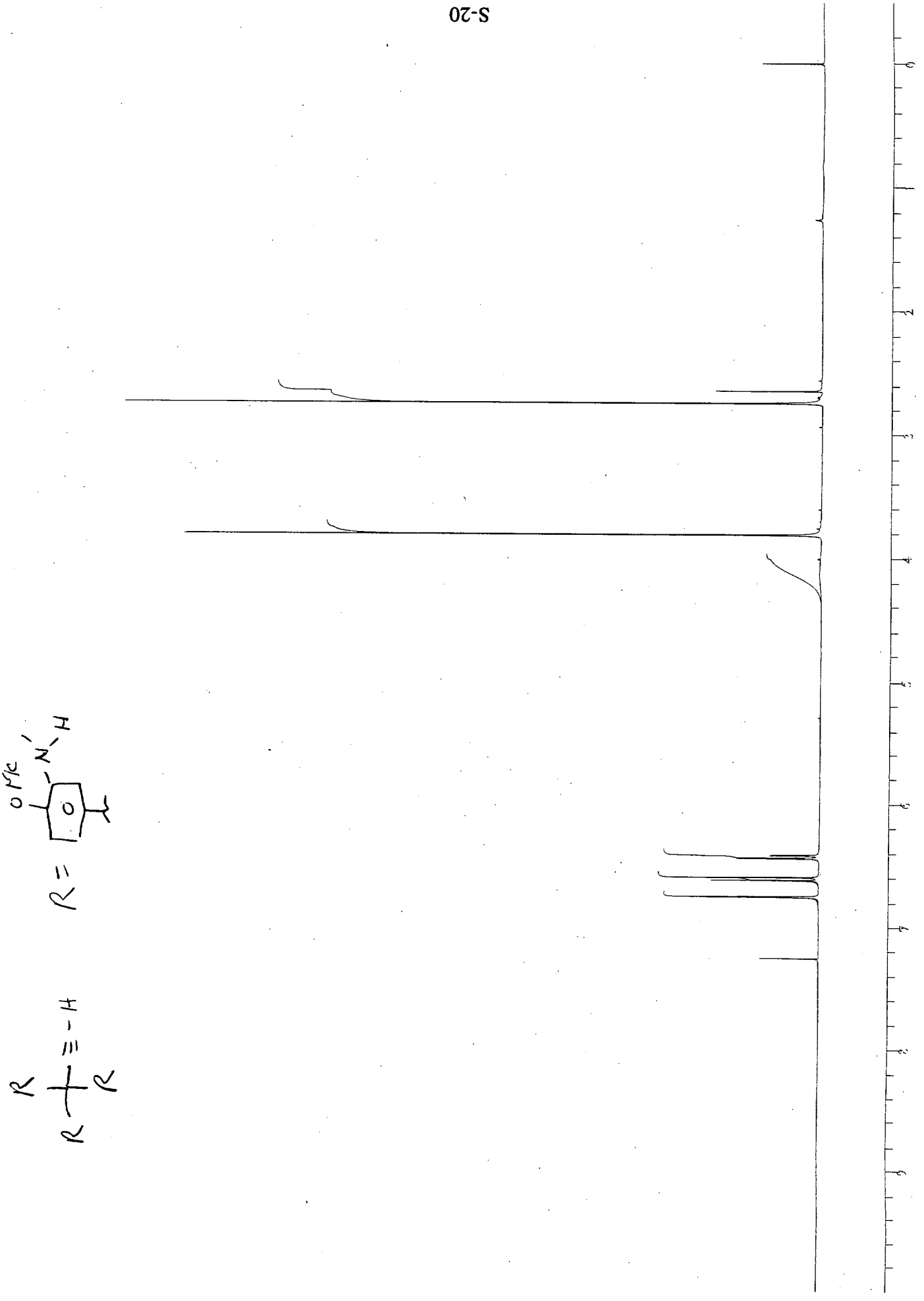

TEG-I -226

ppm	Hertz	Height
158.044	15901.213	Threshold
17.455	1756.219	8.303
145.650	14654.248	79.087
138.587	13943.658	55.170
138.452	13930.034	57.366
117.279	11799.796	98.756
111.086	11176.706	97.030
107.986	10864.733	94.727
91.323	9188.297	19.238
77.315	7778.911	198.229
76.997	7746.914	196.185
76.679	7714.910	169.790
72.090	7253.201	35.101
55.379	5571.871	117.766
54.777	5511.238	15.721
30.408	3059.412	108.733